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Food & Nutrition Research Briefs

Is There a Copper/Aging Connection?

A new thesis suggests that too little dietary copper—common in industrialized countries—may contribute to aging. The thesis is based on animal studies bolstered by indirect evidence. ARS researchers are finding evidence that copper deficiency spurs sugar molecules to attach to protein molecules. The process, known as protein glycation, is thought to cause much of the tissue damage in people with diabetes. And this glycation increases in all of us as we age.

When blood sugar is high, as often occurs in copper-deficient rats, it's more likely that sugar molecules will attach to proteins—called early glycation. If sugar levels stay high, the sugars' free ends can attach to other proteins or other sites on the same protein—called advanced glycation. These cross links bend proteins out of shape, rendering them useless.

Researchers found that both the early and advanced stages of protein glycation increased significantly in rats fed a copper-deficient diet. One sensitive indicator of advanced glycation was at least sixfold higher in the copper-deficient rats. It was nearly undetectable in the control rats, they reported in the *Journal of Nutritional Biochemistry,* 1999 (vol. 10, pp. 210-214).

Human diets contain relatively more copper than the rat diets. But the average copper content of U.S. diets falls below the suggested range of 1.5 to 3.0 milligrams daily. The researchers speculate that years of eating a diet low in the mineral may contribute to the age-related decline in tissue function by increasing glycation. So far, they have looked only at glycation of blood hemoglobin and serum proteins. But it can also happen to structural proteins that form the tissues. High-copper foods include whole grains, oysters, liver, nuts (particularly Brazil nuts), seeds, cocoa and chocolate.

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Athletes Need Just Enough Zinc

Peak athletic performance depends on adequate zinc, according to a study of the effects of a low-zinc diet on 12 athletic men in their twenties. While most athletes don't have to worry, those who avoid beef and load up on carbohydrates may fall short in zinc. Beef is the major source of this essential trace element in the U.S. diet. Wrestlers, gymnasts and ballerinas who eat sparingly to maintain a low body weight may also be at risk of too little zinc. The recommended 12-15 milligrams per day is adequate for peak performance. Supplementing with several times that level can cause health risks.

The study focused on a zinc-containing enzyme—carbonic anhydrase—in red blood cells. The enzyme helps red blood cells pick up carbon dioxide and drop it off in the lungs to be exhaled. This exchange helps maintain the chemical environment muscle cells need to contract and produce energy. If the exchange is sluggish, the athlete pays the price in performance.

For nine weeks each, the men ate a diet containing 18 mg of zinc daily and another containing only 3 mg. After the low-zinc diet, the activity of the carbonic anhydrase enzyme was lower. The men had significant drops in peak oxygen uptake and peak carbon dioxide output as they cycled all-out on an ergometer. Their respiratory exchange ratios also dropped, indicating energy production during peak exercise was not up to snuff. The low-zinc diet also depressed these measurements while the men cycled at 75 percent of peak capacity.

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Balance, Memory Losses Restored in Aging Rats

Getting blueberry extract daily for eight weeks reversed some loss of balance and coordination in aging rats. And it improved the animals' short-term memory, as did strawberry and spinach extracts, researchers reported in the *Journal of Neuroscience,* 1999 (vol. 19, pp. 8114-8121). The 19-month-old rats were the equivalent of 65- to 70-year-old humans. They ate the human equivalent of at least a half cup of blueberries daily.

The most significant findings are the improvements in coordination and balance, the researchers say, because

little else has reversed deficits in motor function. They attribute the reversals largely to improvements in nerve cell signaling in the neostriatum—an area of the brain that controls both motor and cognitive function. The same researchers earlier reported that high-antioxidant fruits and vegetables prevented some loss of function in aging rats (see April 1999 *Food & Nutrition Research Briefs*).

The findings hold hope for older people. Memory and motor function are among the first to go in humans as well as rats. Blueberries score highest in the ORAC assay, with strawberries and spinach in the top seven. Other high scorers include prunes, raisins, kale, blackberries and raspberries. ORAC measures the ability of foods, blood plasma and just about any chemical mix to subdue oxygen free radicals in the test tube. These oxygen radicals can damage cell membranes, DNA and other delicate machinery and are blamed for many of the dysfunctions and diseases of aging.

In the study rats, motor function starts to decline at about 12 months and is obvious by 15 months. By 19 months, the length of time these rats are able to traverse a narrow rod before losing balance normally drops from 13 seconds for a young rat to 5 seconds. After getting the blueberry extract, the rats stayed on the rod for an average 11 seconds.

Daily doses of strawberry and spinach extracts improved short-term memory about as well as the blueberry extract, but none improved long-term memory. For humans, an example of short-term memory is the ability to remember a phone number long enough to dial it.

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Attacking Heart Disease at Its Genes

Some day, health professionals will have a fairly complete profile of the human genes that influence heart disease risk. Individuals could then adopt the habits most likely to reduce risk because different genes or combinations of genes respond differently to changes in diet, exercise, smoking, alcohol consumption or medications such as cholesterol-lowering drugs.

One pioneer in this field—located at the ARS center in Boston—focuses on genes that control blood lipids. His team has identified several of the 40 or so genes so far known to affect cardiovascular health. He estimates that hundreds of genes may ultimately go into a risk-analysis database.

Four main disorders under genetic control contribute to heart-disease risk: high blood lipids, high blood pressure, obesity in the abdomen, and impaired glucose tolerance, resulting in type II diabetes. Whether a disorder manifests itself depends upon an individual's lifestyle and age. Moreover, one gene can affect another. For example, in an obese individual, an obesity gene can trigger a normally beneficial gene for blood lipids to express high LDL ("bad") cholesterol and triglycerides. But if the individual stays lean, the beneficial gene could prevail—all other things being equal.

Such genetic interactions have produced conflicting results in diet intervention studies and led to public confusion over the value of changing one's fat intake. One group that can benfit are people with a genotype known as APOE4, according to the researcher. If they follow the standard cholesterol-lowering diet, they can expect about a 30-percent decrease in LDL cholesterol. That's about the level of decrease expected from cholesterol-lowering drugs—except for people with this genotype. They respond poorly to the best of these drugs.

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Getting Preemies Home Sooner

The level of lactase—the enzyme responsible for the digestion of milk sugar—might help physicians identify premature infants at risk for feeding intolerance, a common complication and main cause of extended hospitalizations. In a recent study of 135 premature infants, lactase activity was a strong indicator of intestinal maturity, which affects an infant's ability to handle feedings.

Premature infants can't be released from the hospital until they are on full human milk or formula feedings. As a rule, they are started on intravenous feedings at birth. Generally after two weeks, they receive supplemental feedings of human milk or special preemie formula, which are gradually increased.

In the study, however, half of the infants began receiving supplemental feedings at four days of age, the remainder at the traditional 15-day mark. At 10 days of age, the early feeding group's lactase activity was double that of the infants receiving only intravenous feedings. At 28 days, it was still 60 percent higher even though both groups were getting similar amounts in their supplemental feedings, the researchers reported in the *Journal of Pediatrics*, 1998 (vol. 133, pp. 645-649).

Infants with the highest lactase activity were most likely to achieve full feedings sooner and least likely to have abdominal complications. Those who received early feedings of human milk had the highest lactase activity.

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Breast Milk Best for Preemies, Too

Premature infants fed breast milk fortified with extra nutrients fare better than those receiving special preterm formulas. That's what researchers found in a study of 108 infants born between 11 and 13 weeks prematurely and weighing less than 2.5 pounds each.

The preemies were fed either a special preterm formula or fortified breast milk, depending on parental wishes. Within each group, milk feedings were initiated at different times, and the tube-feeding method was varied to determine an optimal feeding regimen. Of all the strategies tested, fortified human milk influenced premature infant health the most, the researchers reported in *Pediatrics*, 1999 (vol. 103, pp. 1150-1157).

The infants receiving fortified human milk "graduated" from intravenous to milk feedings faster and had fewer of the complications common in premature infants. For instance, they had fewer infections in the blood and fewer cases of an intestinal inflammation that often requires surgery. They also needed less medication to control spitting up and were discharged from the hospital an average of two weeks sooner than their formula-fed counterparts.

Breast milk contains antibodies and other substances that encourage the growth of good bacteria in an infant's intestinal tract and also inhibit the harmful ones that can invade an infant's system and cause problems. But human milk fed to premature infants must first be fortified with additional protein and minerals like calcium and phosphorus. Before these extra nutrients were added to formulas or incorporated into fortifiers for human milk, premature infants grew poorly and developed bones that fractured easily.

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New Test Pinpoints Animal Antibiotic

A new ARS-patented antibody quickly pinpoints a major antibiotic given to dairy cows and meat animals. ARS researchers developed a new test, using this antibody, to detect the antibiotic Ceftiofur. Ceftiofur is used to treat mastitis in dairy cows and respiratory diseases in cattle, pigs, and poultry.

The federal Food and Drug Administration routinely screens milk, and USDA's Food Safety Inspection Service routinely checks meat products, to make sure they don't exceed the tolerances for residues from antibiotics approved to treat animals. Currently, these agencies measure residues by using time-consuming laboratory analytical methods.

The test, with the ARS-patented antibody called CEFT-116, is much quicker and easier than chemical analyses. It can detect Ceftiofur in the low-part-per million (ppm) range in hundreds of milk samples per day. The immunoassay is reported in *Food and Agricultural Immunology*, 1998 (vol. 10, pp. 121-132). The antibody is licensed to a company for incorporation into an immunoassay for measuring Ceftiofur in milk.

The researchers envision that CEFT-116 can be used alone or incorporated in a test kit along with other antibodies. The advantage of developing an immunoassay kit is that it can be used in the field by the dairy and meat industries as a way to prescreen their products for safety.

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Simulated Gut Measures Iron Available From Food

An artificial gut invented by ARS scientists promises to accelerate knowledge about the amount of iron available from food and food supplements. The system is the first to model in the lab what occurs in the human intestinal tract. The research has already led to suggestions for improving the nutritional makeup of infant formula.

Iron deficiency is the world's most prevalent nutrient deficiency. Even in developed countries, it remains a serious concern for women during pregnancy and childbearing years. Children, too, must receive proper iron nutrition. So researchers developed an in vitro model that couples simulated food digestion with a human intestinal cell line, Caco-2. The model, reported in the *Journal of Nutrition*, 1998 (vol. 128, pp. 1555-1561), allows food digestion to occur simultaneously with opportunity for nutrient uptake by Caco-2 cells.

It is a fast, inexpensive, easy method for determining the relative availability of iron from different foods or from different crop varieties of the same food. So far, researchers have used the system to investigate the iron availability of rice cereal, infant formulas and iron supplements. It should have broad applications for studying staples like rice, corn, wheat and beans; food supplements; pharmaceutical iron preparations, and baby foods such as formula, cereals and purees. With continued improvement, the model may eventually be used to measure the bioavailability of other micronutrients, such as vitamin A, zinc, selenium and iodine.

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Chromium Critical for Glucose Tolerance

Rats raised on a chromium-deficient diet showed the earliest stage of diabetes—high blood insulin levels—in a study recently reported in *Metabolism*, 1999 (vol. 48, pp.

1063-1068). The finding underscores that chromium is necessary for maintaining normal glucose tolerance, the researchers concluded. And it suggests that low-chromium intakes—very common in industrialized nations—may contribute to the onset of Type 2 diabetes mellitus, or middle-age diabetes, over the long term.

The hormone insulin escorts blood glucose into body cells and enables the cells to use that glucose for fuel. Diabetes begins when the cells become less sensitive to insulin. As the cells become insensitive to insulin, the body produces more of it. So high blood insulin is an early indicator of potential diabetes. By the time blood glucose is elevated, a person already has the disease. Chromium is one of the keys to maintaining the cells' sensitivity to insulin. Good sources of the mineral include fortified cereals and whole grain products.

During a glucose tolerance test, rats that got virtually no chromium in their food or water for three months had insulin levels twice as high as a group that got chromium-fortified water or a control group fed a standard chow that contains chromium. In animal studies, the effects of chromium deficiency are seldom obvious until the animals are stressed. The glucose tolerance test with its sugar load was the stressor in this study.

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What Americans of Hispanic Origin Eat

For the first time, food and nutrient intakes of Mexican Americans and other people of Hispanic origin are available from USDA. The data are drawn from the 1994-96 What We Eat in America Survey, also known as CSFII, managed by ARS.

The data show that Mexican Americans eat more fiber than other Hispanics, non-Hispanic whites and non-Hispanic blacks. The average fiber intake for all Mexican Americans was 17 grams daily, closer than the other groups to the 20-30 grams recommended by the National Institutes of Health. Adult Mexican-American males age 20 and over consumed nearly 24 grams of fiber on average, while teenage males consumed nearly 20 grams.

Legumes may contribute a large portion of that fiber in the Mexican-American male diet. Adult males averaged 107 grams of legumes a day. That's double the intake of other Hispanics and almost four times greater than the non-Hispanic groups. Teenage Mexican-American males consumed two to six times more legumes than the other groups, averaging 71 grams daily.

Not surprisingly, Mexican Americans eat more tortillas and taco shells than other Hispanics—about twice as much. The latter group eats three times more rice than Mexican Americans. Mexican Americans also lean toward whole milk, which accounts for 63 percent of milk consumed, compared to 59 percent for other Hispanics, 70 percent for blacks and 25 percent for whites.

Both Hispanic groups were low in the same nutrients as the general population, with intakes of vitamin E, calcium and zinc below recommendations. To view the data tables, visit the web site of USDA's Food Surveys Research Group at: http://www.barc.usda.gov/bhnrc/foodsurvey/home.htm. The raw data are available on CD-ROM from the National Technical Information Service at 1-800-553-6847 (Accession No. PB98-500457).

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